4.6 Geology

This section describes the geologic, physiographic, and seismic characteristics of the Kentucky Pioneer IGCC Demonstration Project site and surrounding area. This discussion also applies to the areas affected by the transmission line.

4.6.1 General Geology and Physiography

The project site is located at the edges of the Outer Bluegrass section of the Bluegrass Physiographic Region and the Knobs Physiographic Region (see Figure 4.6-1). The Outer Bluegrass is present in the western portion of the site. It is mostly composed of interbedded limestone and shales and is characterized by deep valleys with little flat land. The Knobs Region, in the eastern portion of the site, consists of shale, which is characterized by subconical knobs eroded by streams along the inner edge of the plateau uplands. From a geological perspective, no transition zone between the two regions is defined. Elevation at the project site varies from approximately 213 to 245 meters (700 to 805 feet) above main sea level.

The project site is located on the eastern flank of the Cincinnati Arch, characterized by gently up-folding rocks extending from the Nashville, Tennessee, area northward into Canada (see Figure 4.6-2). The site and surrounding area are underlain by rocks of Ordovician, Silurian, Devonian, and Mississippian Periods. The rocks are all sedimentary, dip very gently, and consist of shales, limestones, dolomites, silty dolomites, and calcareous shales.

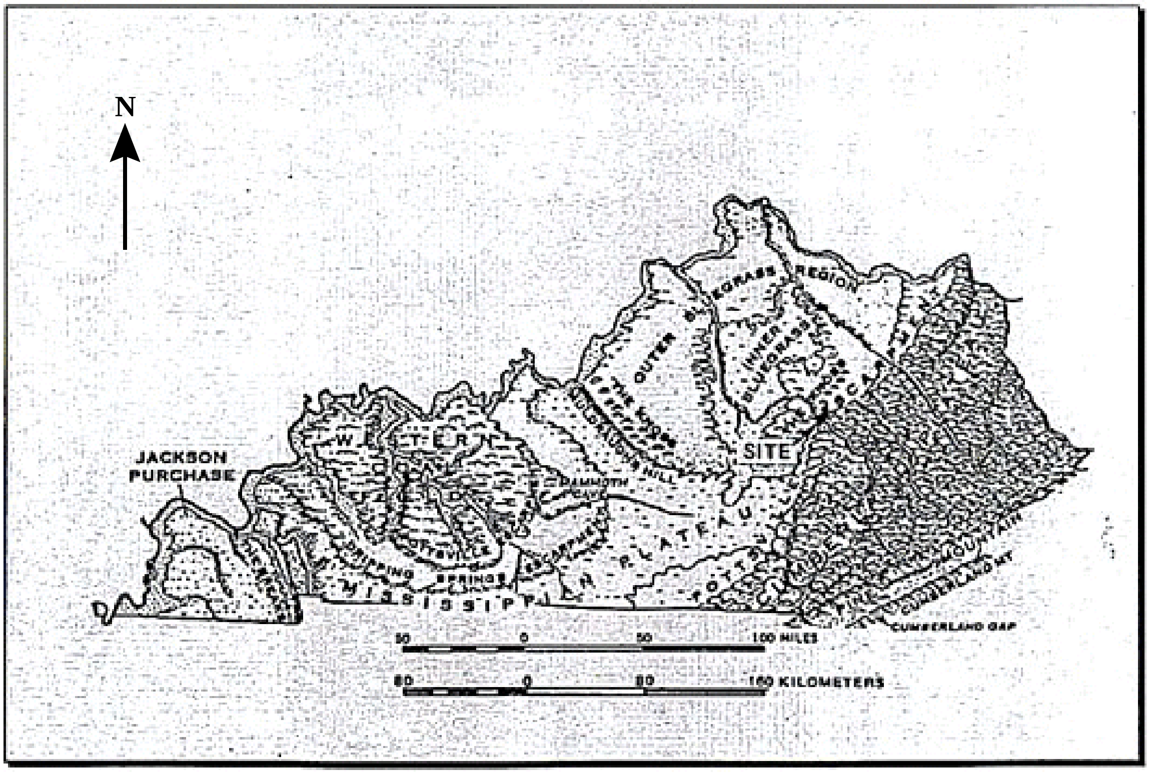
Exposed formations of the Ordovician (490 to 435 million years ago) include the limestone, shales, and dolomites of the Ashlock and Drakes dolomitic shale. In the project site vicinity, the Upper Ordovician Ashlock Formation outcrops are located along the Kentucky River and Bull Run, Upper Howard Creek and Cotton Creek tributaries. Outcrops of the Ashlock Formation are located throughout the area. Silurian formations (435 to 400 million years ago) are in the project area and consist of the Brassfield Dolomite and Crab Orchard formation.

The Devonian Period (400 to 355 million years ago) is represented by the Boyle Dolomite and the New Albany Shale. The Boyle Dolomite is thin to absent in the project area and is underlain by the Crab Orchard Formation. The Boyle Dolomite contains some petroliferous residue. A stratigraphic column showing the formations found in the project area is shown in Figure 4.6-3.

As part of the early site characterization efforts, two borings (depths up to 18 meters [60 feet]) were completed at the project site. Both borings encountered interbedded shale and dolomites of the New Albany, Boyle, Crab Orchard, Brassfield, and Drakes Formation. Bedrock was encountered at approximately 1.5 meters (5 feet) below ground surface.

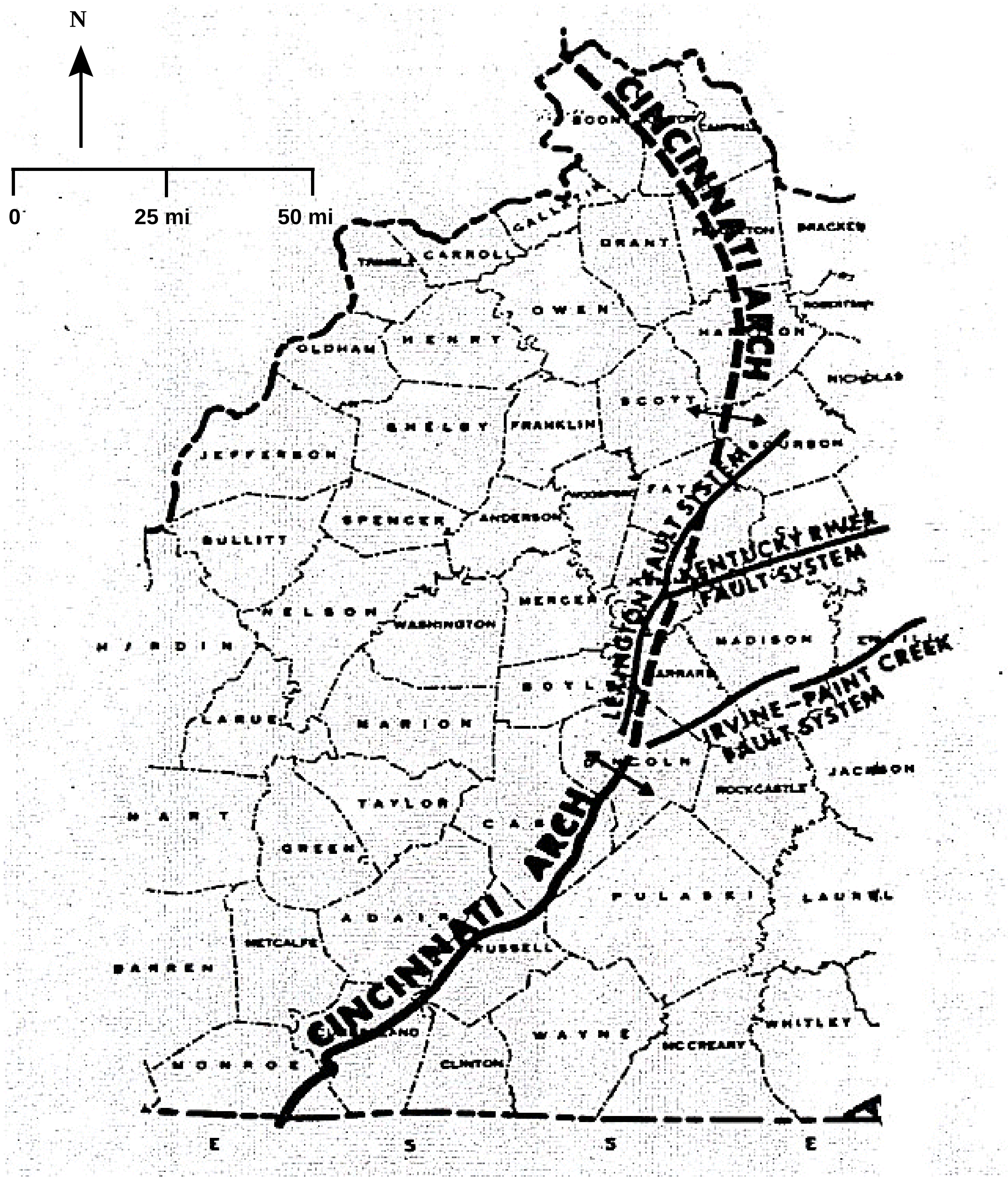
Karst Terrain. On the whole, Kentucky is known to contain large areas of karst. Karst occurs primarily in limestone or where other soluble bedrock is near the earth's surface and fractures in the rock become enlarged when the rock dissolves. This action is behind the development of caves and can lead to depressions of the ground surface or ground failures known as sinkholes.

Karst areas considered to be "highly developed" in the state are located northeast of Clark County in the Inner Blue Grass physiographic region and also in the western portion of the state. These areas tend to have limestone bedrock. Although the surficial bedrock unit at the project site is the New Albany Shale, the project site is located in a broad area categorized as "less developed" karst terrain that extends over much of north-central Kentucky.



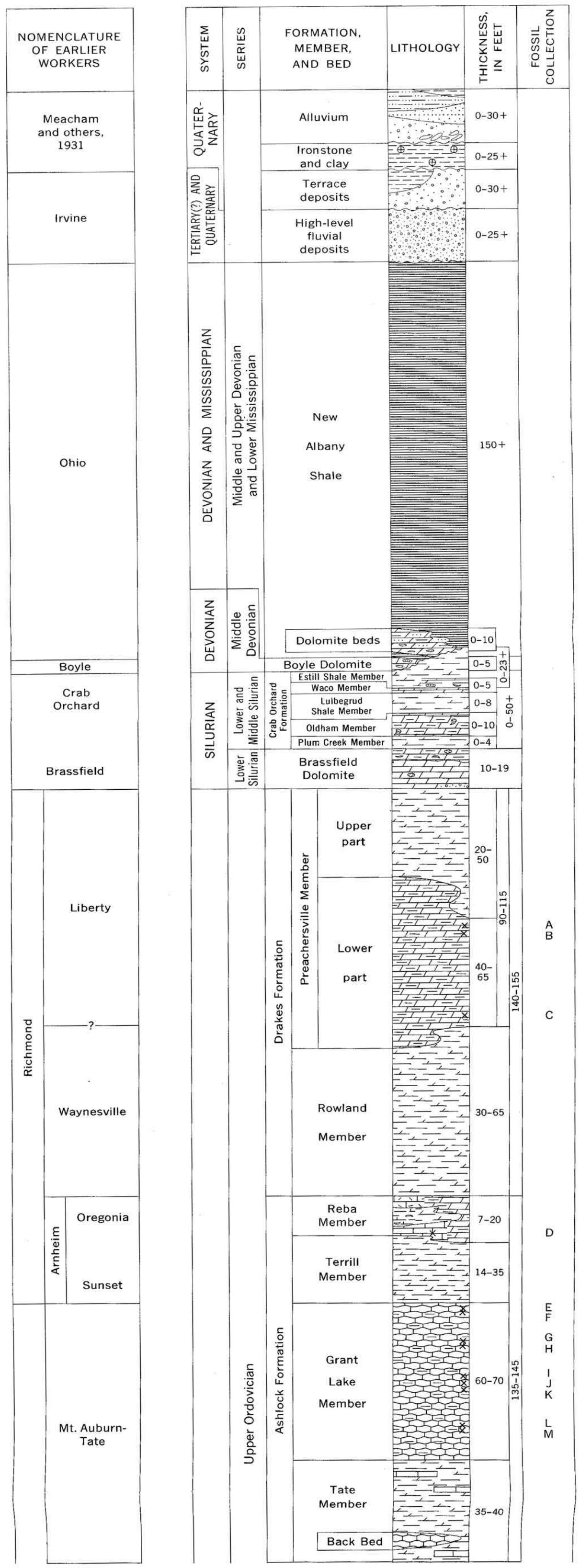
Source: EIV 2000.

Figure 4.6-1. Kentucky Physiographic Regions



Source: EIV 2000.

Figure 4.6-2. Tectonic Features of Central Kentucky



Source: KGS 1975.

Figure 4.6-3. Stratigraphic Column

A map of karst areas in *Ground Water Resources of Clark County, Kentucky* (KGS 2001) divides the county into three karst zones: non-karst, karst prone, and intense karst. The western half of the county is mostly intense karst and includes large areas of limestone bedrock. The southeastern part of the county, including the area east of Trapp, is non-karst; much of this area coincides with areas of New Albany Shale bedrock. On this map, the project site lies approximately at the boundary of the large non-karst area in and around Trapp with a karst prone area. However, this map was prepared using a source map of 1:500,000 scale and thus is not intended for site-specific, detailed use. Given that the project site is located in an area of New Albany Shale bedrock, it may be within the non-karst area depicted on this map.

The site-specific borings installed as part of the initial site characterization effort show that the surficial geology of the project site is the New Albany Shale (extends 3.6 to 4.6 meters [12 to 15 feet] below grade), which is underlain by a thin (0.3 to 0.6 meter [1 to 2 feet]) layer of the Boyle Dolomite. This unit was reported in the two boring logs to be "vuggy" (vugs are small cavities in the solid rock). Beneath the Boyle Dolomite is the Crab Orchard Formation, which is predominately shale with interbedded dolomites that were reported in one of the two boring logs to be vuggy. Although vugs can be conduits for groundwater flow, there is no mention of water in these formations on the boring logs (EIV 2000). In addition, none of the geologic formations found beneath the project site are described as having karst features such as sinkholes, or having underground drainage features, such as solutional enlargement of fractures and bedding-plane openings (KGS 2001).

Structural Geology. The major structural feature in the area is the Kentucky River fault system. This fault system is present in central Clark County and consists of a narrow bank of normal faults and grabens. Four faults are present in the general project vicinity: the Howard Creek fault is located approximately 1.2 kilometers (0.7 miles) southwest of the project site, the Cotton Creek fault is 1.6 kilometers (1 mile) farther to the southwest; and the Eagle Nest and Ruckerville faults are located 3.2 to 4.8 kilometers (2 t o 3 miles) north of the project site, respectively. None of these faults have moved in historic time (KGS 1975). Other faults are associated with the Irvine-Paint Creek fault system, located approximately 50 kilometers (31 miles) south of the project site.

Seismology. The major part of east-central Kentucky, including the project site, is in Seismic Zone 1, a region of limited earthquake activity. The most significant event within 50 kilometers (31 miles) of the site occurred on February 28, 1854, with an epicentral intensity of IV on the Modified Mercalli (MM) index (see Table 4.6-1). The earthquake occurred near Lexington, Kentucky. Lexington experienced another earthquake on February 20, 1869, with an intensity of IV MM; however, the earthquake was not felt in the surrounding areas. The only other earthquakes to have occurred within 50 kilometers (31 miles) of the site occurred on June 6, 1989, and June 26, 1989, near Richmond, Kentucky. Figure 4.6-4 illustrates the epicentral locations of all earthquakes that are known to have had an epicentral intensity of IV or greater in the area defined by the latitudes of 36° North and 40° North and longitudes of 82° West and 86° West (EIV 2000).

The far southwest corner of the area depicted in Figure 4.6-4 is the northeastern-most part of the New Madrid Seismic Zone, a very seismically active area. Historically, this area has been the site of some of the largest earthquakes in North America. One of these was the February 7, 1812, intensity XI-XII MM event that occurred in New Madrid, Missouri. The effects in Lexington (34 kilometers [21 miles] northwest of the project site) were described as severe, but not as having caused any material damage (intensity of VI MM). The return period for such an event has been estimated at between 510 to 1,000 years (EIV 2000). Similarly, an event of intensity IX MM occurred in the vicinity of Charleston, Missouri, on October 13, 1895. Newspapers local to the proposed project site described effects in the area as what is generally accepted to be those of intensity IV MM or less (EIV 2000).

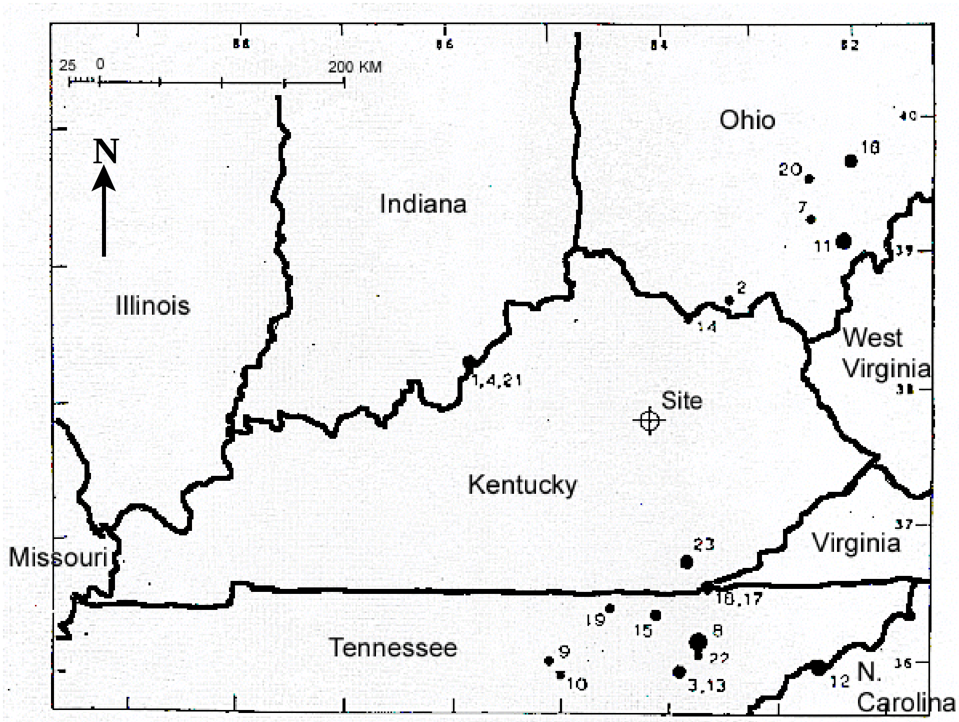
Mineral Resources. According to the Mineral and Fuel Resources Map of Kentucky, there are no geologic resources in the project area (KGS 1998).

Table 4.6-1. The Modified Mercalli Intensity Scale of 1931, With Approximate Correlations to Richter Scale and Maximum Ground Acceleration[a]

Modified Mercalli Intensity[b]	Observed Effects of Earthquake	Approximate Richter Magnitude[c]	Maximum Ground Acceleration[d]
I	Usually not felt	<2	negligible
II	Felt by persons at rest, on upper floors or favorably placed	2-3	<0.003 g
III	Felt indoors; hanging objects swing; vibration like passing of light truck occurs; might not be recognized as earthquake	3	0.003 to 0.007 g
IV	Felt noticeably by persons indoors, especially in upper floors; vibration occurs like passing of heavy truck; jolting sensation; standing automobiles rock; windows, dishes, and doors rattle; wooden walls and frames may creak	4	0.007 to 0.015 g
V	Felt by nearly everyone; sleepers awaken; liquids disturbed and may spill; some dishes break; small unstable objects are displaced or upset; doors swing; shutters and pictures move; pendulum clocks stop or start	4	0.015 to 0.03 g
VI	Felt by all; many are frightened; persons walk unsteadily; windows and dishes break; objects fall off shelves and pictures fall off walls; furniture moves or overturns; weak masonry cracks; small bells ring; trees and bushes shake	5	0.03 to 0.09 g
VII	Difficult to stand; noticed by car drivers; furniture breaks; damage moderate in well built ordinary structures; poor quality masonry cracks and breaks; chimneys break at roof line; loose bricks, stones, and tiles fall; waves appear on ponds and water is turbid with mud; small earthslides; large bells ring	6	0.07 to 0.22 g
VIII	Automobile steering affected; some walls fall; twisting and falling of chimneys, stacks, and towers; frame houses shift if on unsecured foundations; damage slight in specially designed structures, considerable in ordinary substantial buildings; changes in flow of wells or springs; cracks appear in wet ground and steep slopes	6	0.15 to 0.3 g
IX	General panic; masonry heavily damaged or destroyed; foundations damaged; serious damage to frame structures, dams and reservoirs; underground pipes break; conspicuous ground cracks	7	0.3 to 0.7g
X	Most masonry and frame structures destroyed; some well built wooden structures and bridges destroyed; serious damage to dams and dikes; large landslides; rails bent	8	0.45 to 1.5 g
XI	Rails bent greatly; underground pipelines completely out of service	9	0.5 to 3 g
XII	Damage nearly total; large rock masses displaced; objects thrown into air; lines of sight distorted	9	0.5 to 7 g

Source: ICSSC 1995, PPI 1994.

[a] This table illustrates the approximate correlation between the MM scale, the Richter scale, and maximum ground acceleration.
[b] Intensity is a unitless expression of observed effects.
[c] Magnitude is an exponential function of seismic wave amplitude, related to the energy released.
[d] Acceleration is expressed in relation to the earth's gravitational acceleration (0).



Event No.	Date month-day-year	Epicentral Coordinates °N/°W	Felt Area in sq. km (sq. mi)	Intensity (MM)
1	08 07 1827	38.3/85.8		VI
2	03 10 1827	38.7/83.8	550,00 (340,000)	V
3	11 28 1844	36.0/83.9		VI
4	04 05 1850	38.3/85.8		V
5	02 28 1854	37.6/84.5	20,000 (12,500)	IV
6	02 20 1869	38.1/84.5		IV
7	05 17 1901	39.3/82.5	25,000 (15,000)	V
8	03 28 1913	36.2/83.7	7,000 (4,350)	VII
9	06 22 1918	36.1/84.1	8,000 (5,000)	V
10	12 24 1920	36.0/85.0		V
11	11 05 1926	39.1/82.1	900 (560)	VI-VII
12	11 02 1928	36.0/82.6	40,000 (25,000)	VI-VII
13	10 16 1930	36.0/83.9		V
14	05 28 1933	38.6/83.7	1,800 (1,100)	V
15	02 10 1948	36.4/84.1		V-VI
16	06 20 1952	39.7/82.1	13,000 (8,100)	VI
17	01 02 1954	36.6/83.7		VI
18	01 25 1957	36.6/83.7		VI
19	06 23 1957	36.5/84.5		V
20	04 08 1967	39.6/82.5	10,000 (6,200)	V
21	12 11 1968	38.3/85.5		V
22	07 13 1969	36.1/83.7	50,00 (31,000)	V
23	01 19 1976	36.9/83.8		VI

Source: Modified from EIV 2000.

Figure 4.6-4. Regional Seismic Events

4.6.2 Soils

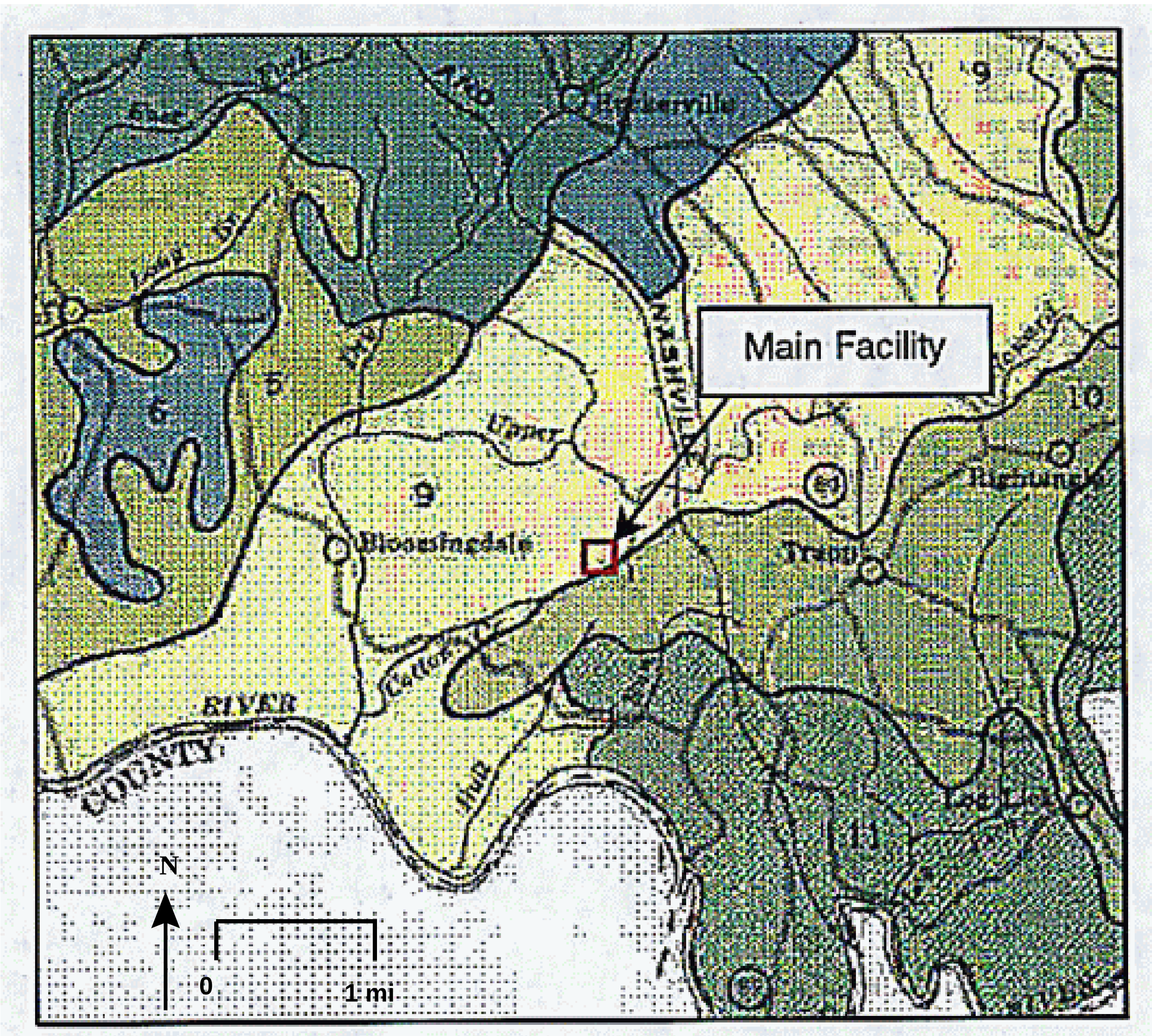
The site contains three soil associations: the Otway-Beasley, the Coyler-Trappist-Muse, and the Otway-Fleming-Shrouts (Figure 4.6-5). Within these three associations, seven different soil series and areas classified as rock outcrop occur on the project site. The dominant soil series found on the site are the Tilsit, Colyer, and Otway; these series are described below.

Tilsit Series. The Tilsit series consists of moderately deep, moderately well-drained soils of upland formed in residuum from acid shale. Most of the areas are on broad, nearly flat ridgetops. The surface layer is generally dark grayish-brown, friable silt loam and the subsoil is slightly firm silty clay loam. These soils are extremely acidic, are medium in natural fertility, and have a moderately low erosion hazard.

Colyer Series. The Colyer series consists of shallow to very shallow, excessively-drained soils of uplands. These soils are underlain by black, acid shale and are found on ridgetops and steep side slopes in rough, broken areas. These soils have a thin surface layer of brown silty clay loam, are extremely acidic, and low in natural fertility. The Colyer soils found at the project site are considered to have a moderately-high to high erosion hazard.

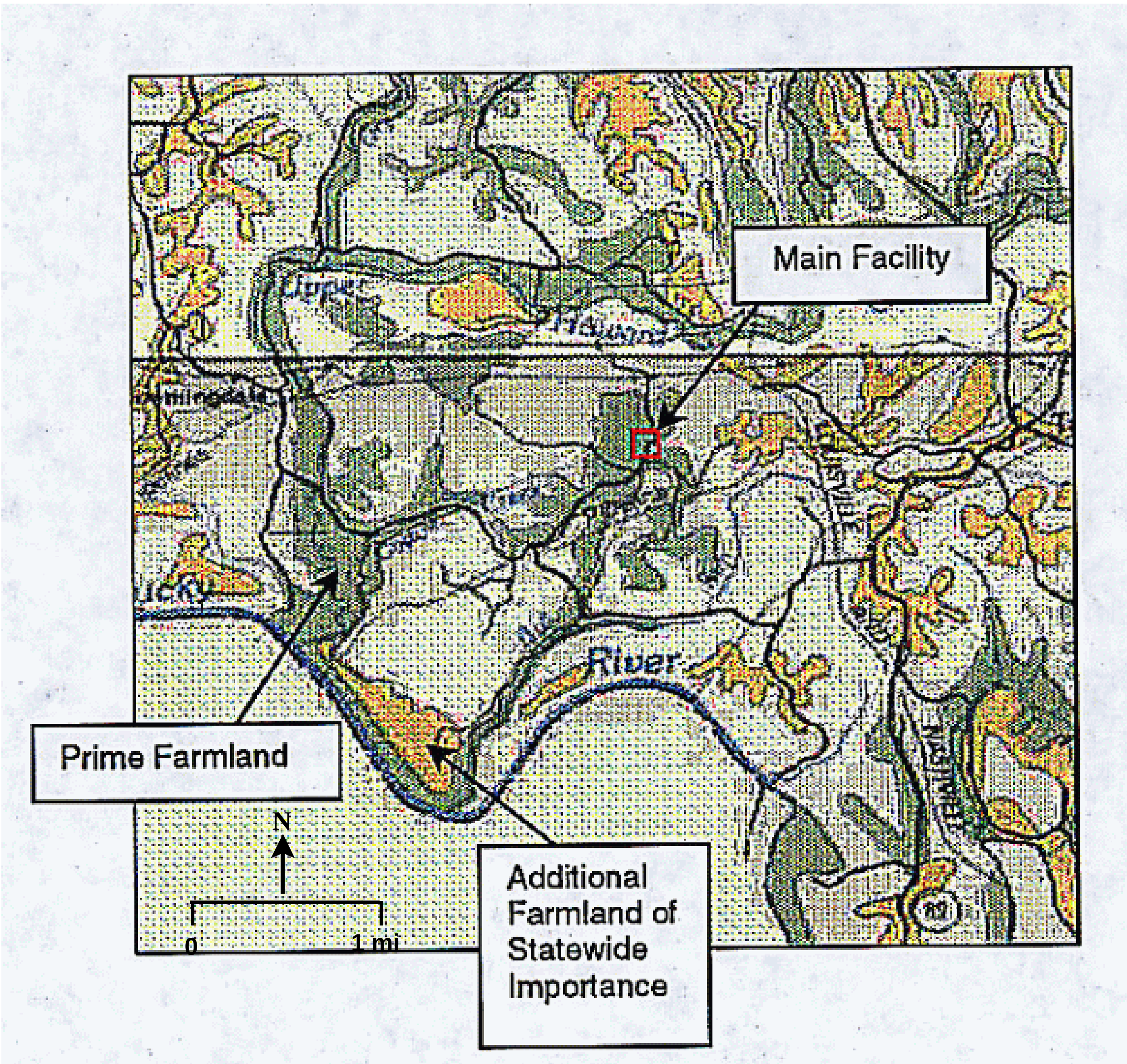
Otway Series. The Otway series consists of shallow to very shallow, somewhat excessively-drained soils of the uplands. These soils are found in rough, broken areas and were formed in residuum from soft, calcareous shale, commonly called marl. The surface layer is a very dark grayish-brown, firm silty clay loam. At the project site, these soils are found on steep side slopes near intermittent streams. In most areas mapped, erosion has removed the surface layer leaving a very firm, silty clay exposed. These soils are highly susceptible to further erosion.

Prime Farmland. Prime farmland is the most productive agricultural land that has the best combination of physical and chemical properties for producing food, feed, forage, fiber, and oil seed crops. A prime farmland area has the moisture and growing season necessary to produce economically sustainable high yield crops when treated and managed according to acceptable methods (UEC 1980). Approximately 100 percent of the site and surrounding area was covered by soils classified as prime farmland prior to site preparation in the late 1970s (see Figure 4.6-6). These soils consisted of Egam silt loam; Tilsit silt loam; Trappist silt loam; Captina silt loam; Allegheny loam; Ashton silt loam; Bedford silt loam; Huntington silt loam; Lindside silt loam; Beasley silt loam; and Neward silt loam (UEC 1980). However, the Clark County Conservation District has determined that southern Clark County does not generally have good cropland and only has a fair potential as pastureland (UEC 1980).



Source: EIV 2000.

Figure 4.6-5. General Soil Map of the Project Site Area



Source: EIV 2000.

Figure 4.6-6. Prime Farmland